THE GEOLOGY OF NEWBRIDGE, NEAR BATHURST, N.S.W.

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(Plates xxii.-xxiii.)

i.—Introduction and Previous Literature.

The village of Newbridge is on the Great Western Railway, 20 miles south-west of Bathurst, and 165 from Sydney. It is the outlet of the mines of the Trunkey and Tuena districts, and may become that of the Rockley and Burraga districts. The country described in this paper includes the Parish of Galbraith, in which Newbridge is situated, and the southern portion of the adjoining Parish of Lowry, in which most of the marble occurs; references are also made to the Caloola gold mines, and the copper mines of Belmore and Cow Flat, which are in the Parish of Ponsonby, still further to the east. The country is hilly but not very rough, and is drained by Reedy Creek, George's Plains Creek, and Queen Charlotte Vale into the Macquarie River.

Five series of rocks are developed in this district:—slates, limestones, chlorite-schist, andesites, and granites; and the mode of occurrence and the description of the varieties of each of these form the subject matter of this paper.

Very little mention has been made of Newbridge district in scientific literature. The boundaries of its several formations are shown rather incorrectly on the Rev. W. B. Clarke's map, and his boundaries are followed in the Geological Survey Map of 1893. Scattered references occur in the Reports of the Department of Mines.* The Rev. J. Milne Curran† has drawn attention to the exposure of the junction of granite and slate in the railway cutting near Newbridge, and has sketched the branching of a granite vein. He has also referred to the diabase‡ at Blayney, an augite-plagioclase-magnetite rock, probably connected with the andesites of this region. Mr. W. J. Clunies Ross, B.Sc., has sketched very approximately the boundary of granite and slate in this district, and has made several observations on the slates.§ Mr. J. E. Carne has reported on the iron ore deposits,|| and his report is quoted by Mr. Jaquet,¶ who also settled the relation of andesites to slates in the neighbouring district of Cadia.** Mr. L. F. Harper reported on the Caloola marbles in 1904.†† Mr. E.

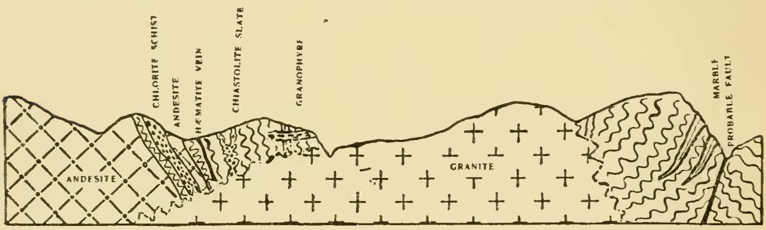

Fig. 1.—Section from A to B on Map (Plate xxii.).

F. Pittman makes references to the iron and marble deposits, and also to the slate quarries both in "The Mineral Resources of New South Wales" (p.446) and in the "Prospector's Guide" (p.16).

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* See list given by Curran in these Proceedings for 1891, (2) vii. pp.175-178.

† *Op. cit.* p.203.

‡ *Op. cit.* p.231.

§ Q.J.G.S. 1894, p.105, *et seqq.*

|| Ann. Rept. Dept. Mines New South Wales for 1892, p.150.

¶ Mem. Geol. Surv. N. S. Wales, Geology. No.2. "The Iron Ore Deposits of New South Wales," p.137(1901).

** *Op. oit.* pp.21-30.

†† Ann. Rept. Dept. Mines N. S. Wales, 1904, p.147.

So far as I know, this is the whole of the work that has been done on the Newbridge district; and no detailed description or map of the formations as a whole has yet appeared.

ii.—The Andesites and Asbestos.

The south-western portion of the Parish of Galbraith is andesite. At its contact with the slate it becomes laminated and very decomposed, so that the distinction between decomposed slate and decomposed andesite is often difficult. It is, therefore, not quite certain whether the andesites are intrusive into or interbedded with the slates. I have not noticed branching andesite veins, as might be expected in an intrusion; and there are frequent examples of long, narrow bands of slate among the andesite. These Newbridge andesites appear to be continuous with those of Cadia, and their microscopical characters are similar. The Cadia andesites are stated by Mr. J. B. Jaquet to be interbedded with the slates.* I, therefore, am inclined to believe that the slates are interbedded with the andesites, that is, the andesites formed a series of contemporary flows. In the absence of any fossils in the adjacent slates, we cannot say whether the slates are Silurian or Ordovician. Mr. Jaquet classes those of Cadia as Ordovician.

The boundary of the andesites crosses the Trunkey Road near the southern limit of the Parish. It runs from there up to the point where the railway crosses Reedy Creek. Thence it runs in a north-westerly direction for about three miles, beyond which it was not traced. The rock outcrops fairly well near the boundary, but away from it the outcrops are few. The rock-mass as a whole must be fairly porous. A strong spring of pure water runs (September) at the top of Smith's Hill.

An exact petrographical description of the Smith's Hill andesite is as follows:—

Macroscopical.—Hard, compact, light green rock, with pyroxene and felspar phenocrysts.

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* "Iron Ore Deposits of New South Wales," 1901, p.21.

Microscopically, it is seen that the rock was originally made up of augite and felspar phenocrysts, with subordinate ilmenite, set in a felspathic ground-mass. Subsequent alteration has changed all the ilmenite into leucoxene, and the felspathic base has become partly epidote and sericite. The phenocrysts of felspar are still determinable by their extinction angles, and are andesine. The augites are beginning to be converted into epidote and chlorite, the action commencing at the border, and leaving the centre of the crystals unaltered. They are frequently twinned parallel to 010, and occasionally diagonally. Radiate aggregates of chlorites in green and brown spherulites also occur. There are a few crystals of pyrites, but iron ores are very subordinate. A microphotograph of this rock is shown on Plate xxiii., fig. 1.

The andesites developed here are a portion of a large area of intermediate rocks, which runs west to Blayney. In it several important mines are situated, notably those of Cadia. Two rock descriptions by Mr. Card* show the similarity of rocks of this district with those of Newbridge.

(*a*) Annadale Copper Mine, Blayney.—"These are augite-andesites in different stages of alteration, the alteration taking the form of a development of epidote and to some extent chlorite." (*b*) Mt. Sugarloaf.—"These are andesites, showing a development of epidote, and containing hornblende. I am of the opinion that the hornblende is very probably of secondary origin, resulting from the paramorphic change of the augite. The augite in the specimen is distinctly uralitic."

The andesites of the Canoblas are not a portion of this area, but are of a much later age.

In the south-western portion of the Parish, and in or near Portion 17, there is an occurrence of asbestos. It is in veins about half an inch wide, running through decomposed andesite. The fibres are short, rarely three inches long, and rather brittle. The asbestos is quite anhydrous, and has the optical properties of tremolite. It is probable that it has been formed from the augite of the andesite by uralitisation and solution.

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* Rec. Geol. Survey N. S. Wales, iv., p. 159.

Besides the locality mentioned above, it occurs in Portion 5. Here the rock is less decomposed, and the fibres are not separable.

iii.—The Granites, Granophyres, and Aplites.

The main mass of the granite in this district lies in the north-eastern portion of the Parish of Galbraith, and north and north-western portions of the Parish of Lowry, though its boundaries in the latter Parish have not yet been mapped. In the preparation of this paper, little work was done on the granites of the main mass; and the rocks here described are almost entirely from the innumerable granitic veins that intrude the slate. Before passing to their particular description, I may remark that the granites of the main mass are much decomposed, and show few good outcrops except at or near their junction with the slates. They appear to be much intersected by aplite veins, which, decomposing, are very like red sandstone in appearance. I learn from Mr. T. C. Dwyer, B.Sc., that around Wimbledon, to the extreme north-east of Galbraith, coarse pegmatite is abundant. Near the boundary of the massif basic segregations are very common; the rock in which they are situated is generally a fairly coarse-grained (2-4 mm.) hornblende granite, with large orthoclase phenocrysts. The segregations are usually spheroidal. A particular description of one is as under :—

Macroscopical.—Fine-grained, dark blue granite.

Microscopical.—Hypidiomorphic granular, with predominate oligoclase, and subordinate microcline, orthoclase, and quartz. Small phenocrysts of these last three occur, and larger ones of oligoclase. The coloured minerals are hornblende, green and twinned, with brown biotite much less abundant. Magnetite also is present. Sphene occurs in brown, pleochroic crystals, passing into leucoxene. Apatite needles are frequent.

Coming now to the granitic veins, these seem to run in a general north and south direction, but branch a good deal. Two of these (the westernmost that cross the railway) were traced as far as possible, as shown on the map (Plate xxii.). They did not pass either into pegmatites or quartz veins. Curran gives sketches of several other veins so traced.* It is noticeable in the railway cuttings that generally the granite veins follow the cleavage of the slate, and have straight and parallel bounding walls of slate. But this rule is by no means universal, for many irregular intrusions are to be seen, and even horizontal veins occur. We may divide the veins into three classes, (a) granitic, (b) granophyric, and (c) aplitic.

(a) *Granitic Veins.*—These are the most abundant of the veins that cross the railway cuttings. Many of them are very highly decomposed. Some are only partly decomposed, and may still be examined microscopically. Such an one occurs at the 162¾-mile peg on the new line. It intrudes the slate very strongly, as may be seen from fig. 2, which is from a sketch taken in the old railway cutting near by. In Plate xxiii., fig. 3, a microphotograph of the junction of the mica schist with the granite is shown. Microscopically the granite is seen to be composed of predominate orthoclase, with oligoclase, quartz, biotite, muscovite, and apatite.

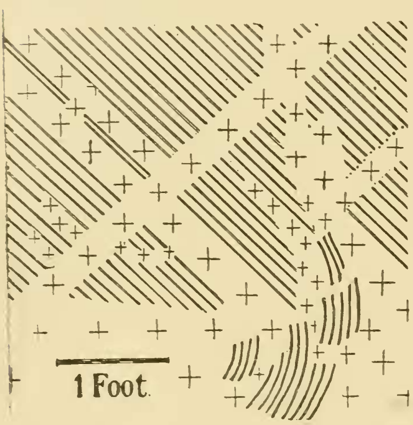

Fig. 2.—Intrusion of mica schist by granite. Sketch in the railway cutting.

In the Railway reserve and near to the boundary fence of Portion 65, Parish of Galbraith, there is a large vein of a beautiful, fresh hornblende-granite. Its exact description is :—

Macroscopical.—Medium-sized grain (1 mm.) showing quartz and felspar, with abundant short prisms of hornblende, some biotite, and occasionally pyrites.

* These Proceedings, 1891, (2) vii.

Microscopical.—Fabric hypidiomorphic granular. The minerals composing the rock arranged in descending order of abundance are :—quartz in fairly large grains with inclusions of apatite. Plagioclase, in large and small crystals, fairly idiomorphic, and sometimes zoned, probably oligoclase. Orthoclase in rather large, slightly decomposed crystals, fairly idiomorphic; twinning is infrequent. Hornblende in green pleochroic and idiomorphic prisms, occasionally twinned; characteristic six-sided basal sections occur. Biotite in large brown pleochroic flakes, frequently intergrown with the hornblende; in one instance a biotite flake appears in the centre of a perfect basal section of hornblende. Sphene in brown to red-yellow pleochroic grains, often approximating to the idiomorphic lozenge-form. Magnetite in cubes and irregular grains. Apatite and zircon.

Besides these granites, there are other rocks more satisfactorily referable to the granite-porphyries. Such a rock is that in a vein crossing the railway at the 162-mile peg. The vein is decomposed, and contains large, spheroidal boulders, segregations of a pink granite of the following description :—

Macroscopically coarse-grained, with quartz, pinkish felspar, and hexagonal biotites, easily recognisable. Large orthoclase phenocrysts are present.

Microscopically, the fabric is microporphyritic, showing the above minerals, and also twinned and zoned oligoclase and microcline. The biotite is very subordinate and is passing into chlorite; apatite occurs.

Another, and perhaps a more typical granite-porphyry, is that which forms the boulders marking the outcrop of the largest granite vein shown on the map (Plate xxii.); it is near the 164$\frac{3}{4}$-mile peg, and is about 70 yards wide, and half a mile long; and forks at the southern extremity. The main mass of the vein is decomposed, the fresh boulders only being capable of sectioning. The precise description of the rock is :—

Macroscopical.—Fine- to medium-grained brownish granite, showing quartz, felspar and biotite.

Microscopical.—Fabric microporphyritic. Ground-mass: quartz and orthoclase in a fine granular base, with no sign of granophyric intergrowth. Phenocrysts: predominant oligoclase, almost idiomorphic and slightly decomposed; untwinned orthoclase crystals; quartz with shadowy extinction, and strongly pleochroic biotite occur, the last changing into chlorite. Muscovite is present, but appears to be due merely to the decomposition of the felspars.

(b) *Granophyric Veins.*—There are several rocks present in this district which may be classed as granophyres. One of them immediately adjoins the granite-porphyry last described. It also has been traced as far as possible; it crosses the railway about 100 yards east of the 164¾-mile peg, and is about two yards thick. It bends round to the N.W., and runs about a quarter of a mile before it is lost to sight.

Macroscopically it is a fine, even-grained, (0·5 to 1 mm.) hard, bluish rock in which only quartz and felspar are recognisable.

Microscopically it is seen to be composed of plagioclase, orthoclase, and subordinate quartz. Biotite is present in small greenish flakes, and muscovite also, the latter being derived from the decomposition of the felspar. The plagioclase is predominant in fairly idiomorphic crystals, probably oligoclase, though the twinning is not very distinct. The orthoclase is idiomorphic, and generally twinned. The quartz is usually very irregular in shape, but in one or two instances shows an hexagonal section, with included biotite fibres placed parallel to the prism faces. The ground-mass is almost entirely quartz and orthoclase in a very fine micrographophyric intergrowth generally arranged radiating from some crystal, not a mica, as centre; that is, a pseudospherulitic structure. Apatite is an accessory mineral, and there is a little magnetite.

In another specimen from the same vein, however, the granophyric structure is almost entirely absent, its place being taken by a fine-grained mixture of quartz and orthoclase, like the "panidiomorphic" structure of aplites. Also in this specimen the twinning of the plagioclase phenocrysts is more distinct, following both the Albite and Carlsbad laws. Zoning is common in felspars, and chloritisation has just started among the biotites. This latter specimen would be more correctly classed as a micro-granite. The former is a true granophyre.*

The second occurrence of granophyres is in the railway line near the 163¼-mile peg. It is in the form of a long, nearly horizontal vein of which about 80 yards are exposed in the cutting. Should it be carefully traced, I believe it will be found to extend for some distance, as specimens of a macroscopically very similar rock occur nearly one mile to the south at George's Plains Creek. It intrudes the slate very strongly, as may be seen in Plate xxiii., fig.4. A precise description of the rock is:—

Macroscopical.—Fine-grained base, with small phenocrysts of quartz and hexagonal biotite, and very large crystals of orthoclase an inch or more long.

Microscopical.—Large crystals of plagioclase almost idiomorphic, and small allotriomorphic phenocrysts of orthoclase, both with dusty inclusions; irregular grains of quartz also occur.

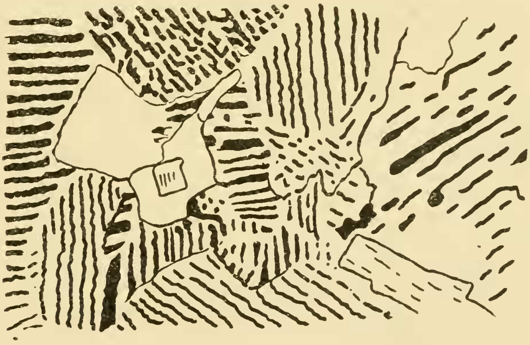

Fig.3.—Intergrowth of quartz (black) and felspar showing Baveno twinning. Highly magnified.

There is in my section one grey, hexagonal, isotropic section of garnet. Small flakes of mica and grains of magnetite are present also. In between all these crystals is a base of "panidiomorphic"

* Teall, British Petrography, p.292.

quartz and felspar, fine-grained, also a little muscovite; and there are large patches of intergrowth with a net-like structure of quartz and orthoclase, rarely pseudospherulitic, but frequently arranged perpendicular to the sides of a square, that is divided into four diagonally. Fig.3 is a sketch of such an intergrowth. This appears due to the Baveno twinning of the felspar crystals, with which the quartz is intergrown, as suggested to me by Dr. Woolnough. Other examples occur in which the quartz crystals are arranged like the barbs of a feather. This is perhaps referable to Carlsbad twinning of the enclosing felspar.

The most remarkable of the granophyres that I have seen in this district is that which occurs in a vein 30 feet wide, crossing the railway line at the 162¾-mile peg. Macroscopically it is a hard, white, apparently felsitic rock, with thin flakes of biotite. Microscopically (see Plate xxiii., fig.2) it is almost entirely orthoclase, containing every variety of graphic intergrowth of quartz, from the development of very small pear-shaped quartz grains forming long strings, up to large fishhook-like patches of quartz imbedded in orthoclase. Quartz also occurs in phenocrysts. There is a little muscovite in square flakes, and long pleochroic strips of biotite.

It is believed that this is the first record of granophyre from the neighbourhood of Bathurst.

(c) *Aplitic Veins.*—Aplitic veins are fairly common, both in the granites of the massif and intruding the surrounding slates. In the slate near the George's Plains Creek (Railway Reserve near Portion 65, Galbraith) there is a vein of pink aplite containing quartz and felspar, with but few grains of biotite. It is fine-grained (1mm.). It cuts through an older vein of the same mineral composition, but of much coarser grain (5 to 10 mm.). The felspar seems to be mostly orthoclase. This association of a fine-grained aplite vein cutting a coarse-grained aplite vein also occurs on the Wimburndale Creek, at the point where the Peel Road crosses it, some nine miles north of Bathurst. The finer-grained rock there is almost identical with the Newbridge aplite above. It is composed of predominant orthoclase, with oligoclase and microcline, and also quartz in irregular grains. There is a little granophyric and pseudospherulitic intergrowth of quartz with orthoclase. Very subordinate biotite occurs, and some apatite.

Age of the Granites.—From the evidence obtainable in the district here described, we cannot fix the age of the granites more definitely than post-Silurian. From their examination of the whole Bathurst district, both Ross and Curran believe that it is probable that the granites are the result of two intrusions, the first pre-Devonian, the second post-Devonian.

iv.—Chlorite Schist.

The chlorite schist occurs, as before noted, in a wide band, one-quarter of a mile west of the Newbridge Railway Station. It runs in a northerly direction, crossing the present railway cutting, appearing again in the old railway cutting; and fragments of the schist are enclosed in a quartz vein about half a mile west of the slate quarry on Reedy Creek. It is so soft that it does not form an outcrop, and so can be examined in the railway cutting only.

Macroscopical.—Green and yellow striped, fibrous, splintery, highly cleaved in three directions, falling into acute rhombohedra, translucent and wax-like to the touch.

Microscopical.—Composed of talc in white, strongly birefringent fibres, running through and occasionally forming subradiating bunches in a predominant ground-mass of green pleochroic chlorite of very low, double refraction

With a magnification of 400 diameters numerous aggregates of brown rutile needles are to be seen, and also some zircons.

Until a more extensive examination has been made in the field and laboratory, I can offer no explanation of the origin of this peculiar rock.

v.—Slates.

The slates of this district lie in a wide band, running in a S.W. direction across Galbraith Parish, between the andesites and granites, by the latter of which they have been intruded. They are the oldest rocks exposed in the district. In age they are probably Silurian, the only fossil recognisable being a Pentamerus found in the interbedded limestones; but it is quite possible that much of the slate is Ordivician,* though so far I have seen no sign of graptolites. As to whether they are highly contorted or not, I have little evidence. Slaty cleavage is developed to such an extent that all sign of the original stratification is lost. The strike of the cleavage is very variable, ranging from N.N.W. to N.N.E., and the dip east or west at 50° to 90°. From examination of the Caloola limestones, I believe the true stratification strike to be N.N.E. and S.S.W. Should the andesites be interbedded with the slates and not intrusive into them, we should be able to use their junction with the slates to give us the true dip and strike; and by this test it would seem that, at the junction, the dip was to the east at 70°, but that the strata were rather contorted; though as previously pointed out the distinction between decomposed andesites and decomposed slate is rarely clear at their junction.

In this region the slates contain fissure-veins filled with iron ore (detailed later), and in one place indications of a copper lode; and are netted with many quartz veins. One of these veins is so notable as to merit description. It is first seen capping a small rise by the road-side in Portion 10, Parish of Galbraith, though it does not occur in the road-cutting below, where there is a wide band of soft pipeclay which represents the slate out of which the silica was bleached to make this great vein. The leaching out of the silica was also accompanied by a removal of the iron, for the pipeclay is nearly white, and the iron is segregated in a vein of siliceous hæmatite near by. The quartz capping the hill is almost pure. As we pass to the north-west, we cross a small valley where there is no sign of the reef. It occurs again on the top of the next hill (Portion 35) among the andesites, and forms a great scarp or wall running down the hillside. It does not occur in Reedy Creek, but forms a large patch (not marked on the map) on the flank of Smith's Hill opposite. Hence the vein forms what may be called a horizontal pipe vein.

* J. B. Jaquet, "Iron Ore Deposits of New South Wales," p.20.

Sufficient field-work has not been done to ascertain whether the quartz veins are continuations of granitic veins; the two granite veins traced do not pass into pegmatite or quartz. This point appears to be well worth investigating in view of the differences of opinion that exist as to the origin of pegmatites. Also, were the quartz veins shown to be connected with the granitic intrusion, it would completely settle the question as to the relative ages of andesite and granite.

At the Caloola Gold Mine there is in the slate a large fissure some 30 feet across, and extending probably to a great depth. This is filled up with soft mud in which are embedded rounded, and apparently waterworn, pebbles of various rocks, some rather similar to the Devonian quartzites. It seems probable that this is a fault crush-conglomerate.

Also at Caloola is the curious feature of a highly crumpled slate lying between walls of quite straight laminated rock. The dip and strike of the slate varies greatly within a hundred yards of the mine, but broadly it may be said to be easterly at 45°.

To describe these slates petrographically, they can be divided into seven distinct groups with varieties, each of which has a sufficiently characteristic appearance in hand-specimen to distinguish its members; and also each group or variety possesses an almost constant microscopic character. Each group may be described in order, dealing with its petrography and distribution in the field; and an attempt will be made to show the origin of each kind of slate. The seven groups are:—

Blue Slate (varieties, Green Slate and Oxidised Slate), Quartz Schist, Augen Slate, Felspathic Slate, Knotted Slate (variety, Spotted Slate), Chiastolite Slate, and Mica Schist.

i. *Blue Slate.*—Macroscopic characters: hard, fissile, blue, fine-grained; thin flakes have a translucent green colour and semi-lustrous waxy appearance. Some specimens have small cubes of pyrites developed. In the field this rock goes in a narrowing band southwards. It forms the whole hill in which the slate quarry (on Portion 42, Parish Galbraith) is situated, and runs down along Back Creek nearly to Newbridge. It also goes north of Reedy Creek towards the Dry Diggings for some distance (see Map of the Distribution of the Slates, fig.4).

Microscopically, it is very fine-grained, consisting chiefly of quartz, some of which shows strain-structure. It is generally all of one size, though certain bands of coarser grain run through

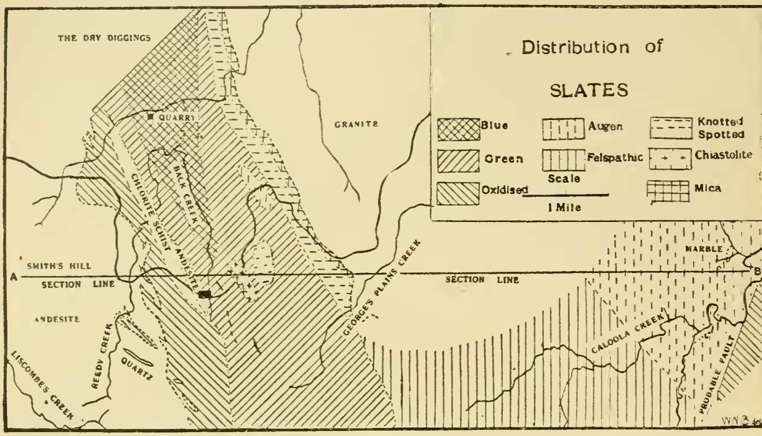

Fig.4.—Sketch map showing the distribution of the various kinds of slate.

the rock. Some of the quartzes contain liquid inclusions. The effects of rock-flowage, as described by Van Hise,* are frequently very marked. Biotite runs through the slide, segregated into bands which are nearly parallel, the direction being that of the cleavage of the slate. Some of the bands are wavy, in which case the quartz grains on the convex side are smaller than those on the concave. The biotite is generally brown, highly pleochroic, and birefringent, though the process of chloritisation, which has just started, renders these properties less marked. The biotite crystals are oriented parallel to the slaty cleavage. In the bands of biotite there is also a little carbonaceous matter, and probably some magnetite. A few grains of andalusite occur, which are

* ' Treatise on Metamorphism." Monograph xlvii. U. S. Geol. Surv. Chap. viii., p.748.

recognisable by their high refractive index and low double refraction. Tourmaline also occurs, but is not abundant; scarcely a dozen crystals are present in the type-slide, though other members of the group are richer in this mineral. The crystals are oriented quite without reference to the cleavage plane. In some members of this group a little orthoclase appears to be present. The usual accessory minerals are rutile in fairly short crystals, zircon, and apatite in very small prisms.

Mr. H. J. Meldrum, B.Sc., has analysed the slate in the quarry on Portion 42, a very typical example of this group of slates. He obtained the following figures (A).

	(A)	(B)
SiO_2	68·67	64·77
Al_2O_3	16·99	14·45
Fe_2O_3	1·11	1·84
FeO	1·87	4·54
MgO	2·34	2·34
CaO	2·33	2·33
Na_2O	1·07	1·57
K_2O	2·88	5·03
TiO_2	present n.d.	0·60
H_2O	1·92	1·92
	99·18	99·39*

Analysis B, showing the composition of a biotite slate from Cross River, Minnesota, U.S.A., is added for comparison. It will be seen that the analyses are very similar, the Newbridge slate being richer in silica but poorer in alkalies than the other.

This is the normal slate of the district, being simply the original sediment consolidated. All the other types of slate, except the Augen and Felspathic, may be regarded as metamorphosed Blue Slate.

The varieties of this first group are Green Slate and Oxidised Slate. The former is partly oxidised Blue Slate, and is perhaps the most common slate of the whole area. As will be seen on the map (fig.4), it occurs between Newbridge Station and the

* Rosenbusch, Elemente der Gesteinlehre, p.513.

first great bend in the railway line, where it passes into Augen and Knotted Slates. It also occurs between the slate quarry and the andesites.

Macroscopically, very fine-grained, soft, light grey-green, with good slaty cleavage and lustre. A little limonite is frequently present in the cracks.

Microscopically, almost identical with the Blue Slates; the disposition and size of the quartzes is the same, and also of the biotite crystals. The chemical change is chiefly in the biotite, which has been largely altered to sericite, with the formation of hæmatite and some chlorite. The accessories, tourmaline, andalusite, rutile, zircon, and carbonaceous matter, are present, the last being a widely varying quantity even in slates of the same variety, since probably it was a varying quantity in the original silt from which the slates were formed. Certain members of this variety have special characteristics; one specimen contains a few grains of oligoclase, another a great quantity of finely divided andalusite.

In this subgroup is classed the slate from the Caloola limestones, though it differs from the type in several particulars. It is to be regretted that the specimen was not obtained *in situ*, but only from the quarry débris. In hand-specimen it is of a bright apple-green, rather coarser in grain than most members of this group, slightly lustrous, and with a rather poor cleavage. Microscopically it is chiefly quartz, showing the effects of rock-flowage. Coloured minerals are less common than usual; the biotite has been almost completely chloritised, forming feebly pleochroic flakes of low double refraction. A little actinolite occurs, and some muscovite; but there is little or no hæmatite. Tourmalines are frequent in grey-blue, pleochroic prisms; rutile abundant in comparatively large yellow or brown needles, and andalusite common in well developed, colourless, highly refracting prisms with pyramidal, terminal faces. Zircons occur in the quartz grains.

The second variety of this group, Oxidised Slate, is very abundant. It forms a band running down the eastern boundary of the andesites, and extends from there to the Green Slate zone (fig 4). It is also developed at the Caloola Gold Mine on the east side of the creek, and has been here brought into contact with the Augen Slates. This, I believe, is due to the existence of a fault as suggested previously (p.535).

The Oxidised Slate is the final product of the oxidation of the Blue Slate. At Caloola this zone of oxidation extends down below the level of the creek-bed In hand-specimen it is crumbly, soft and silky to the touch, and yellowed with limonite. Frequently it is recemented near quartz veins, and forms a hard rock. At Caloola it contains large limonite pseudomorphs after pyrites, usually in cubes, but occasionally dodecahedra; on the andesite boundary it is coloured a deep red with hæmatite derived from the andesites.* At this latter point it is soft and friable to a depth of 40 feet, and has lost cleavage and stratification.

The second group is termed Quartz Schist, and there is but one occurrence known to me. It is at Caloola, where it forms the wall of the fault before described. In hand-specimen it is a hard, lustrous, pink and white streaked slate, like shot silk, with a fair cleavage and very fine grain. Microscopically it is almost entirely quartz in very fine grains, cemented by films of haematite and limonite. Sericite occurs in long parallel fibres, and some rutile. Zircons are included in the quartz grains. Rock-flowage structure is not well developed.

From the field-occurrence as well as from the appearance of this rock, I am inclined to believe it is a rather sandy slate which has been crushed during the faulting.

The third group is termed Augen Slate, a name suggested to me by Dr. Woolnough. It occurs typically near the limestones of Caloola, where it forms a broad band running approximately north and south; it also occurs in the hill between Newbridge and the granites crossing the railway in a band 50-60 yards wide, running

* J. B. Jaquet, "Iron Ore Deposits of New South Wales," p.26.

in a northerly direction. In hand-specimen this rock is not unlike the green slates, though greyer and more fibrous; and its cleavage is poor. Its distinguishing feature is the presence of numerous blebs of clear quartz up to one-eighth of an inch in diameter. These grains are nearly round or lenticular, but have rough surfaces and are not smooth as if waterworn. Microscopically it is very like the green slate, and shows the rock-flowage structure slightly developed among the small quartzes, and parallel disposition of the biotite, which is partly chloritised with the formation, in some cases, of hæmatite. Sericite occurs, and comparatively large crystals of a twinned plagioclase, probably oligoclase, which contain inclusions of biotite and sericite arranged in lines parallel to the general direction of schistosity. In another specimen of Augen Slate the felspar appears to be albite. Pyrites occurs in some instances, rutile and zircon usually. Tourmaline is rare or absent. Muscovite is sometimes present, usually inclined to the direction of schistosity. The quartz blebs may be either of one optically continuous grain, or of several grains of different orientation. The lines of biotites may be truncated by the quartz blebs, or may bend round them, or more rarely pass into them. The boundary of each quartz bleb is not a smooth curve, but irregular.

With regard to the mode of origin of the Augen Slates, Curran* terms them conglomerates, and points out that, as the limestones, representing coral-reefs in the old Silurian sea, were doubtless near the shore-line, the Augen Slates, which are generally in the neighbourhood of the limestones, will represent the beach-conglomerates. While this may in part account for the large quartz grains, I am inclined to believe that they are chiefly due to shattering and subsequent recrystallisation under pressure. The larger quartz grains would resist the crushing more than the other grains, or would be broken up only on their surfaces; and during the recrystallisation the large grains would grow at the expense of the smaller. The surface of the blebs is

* These Proceedings, 1891 (2), Vol. vii. p.198.

so penetrated by the grains of other minerals, particularly biotite, that it cannot be supposed to be a waterworn surface.

The fourth group is that of the Felspathic Slates. This is perhaps the most interesting of all the groups. They form a large portion of the southern part of the Parish of Lowry, stretching from its western boundary to near the Caloola quarries; they also occur in a rather unusual form at a point where George's Plains Creek passes from the slates to the granites. Macroscopically, the Felspathic Slates are hard, compact, dark-coloured rocks of rather coarse grain (*i.e.*, the individual grains can be separated by the naked eye), and with poor or bad cleavage, though the parallel arrangement of particles is obvious. Microscopically, they are not unlike the augen slates, showing a granular ground-mass and some comparatively large grains of quartz, with indications of a rock-flowage structure. Biotite is in plenty in green-brown flakes, and muscovite is in smaller flakes. The usual accessory minerals, rutile, zircon, and sometimes magnetite occur; also a good deal of andalusite. Orthoclase and oligoclase are developed in large idiomorphic and abundant crystals, twinned in their usual fashion, and very full of inclusions frequently arranged in bands parallel to the direction of schistosity, and irrespective of the orientation of the felspar crystal.

The unusual variety from the creek is characterised by its very typical rock-flowage structure, and the abundance of large oval masses of orthoclase containing oval inclusions of quartz arranged parallel to the schistosity. Muscovite and magnetite occur. Albite is also present, but subordinate to the orthoclase. Further, long ropy bands of very fine, almost ultra-microscopic, colourless needles go through the rock in the direction of schistosity, but bending in and out among the larger grains. These needles would be called sillimanite were it not that they are not fractured, and are sometimes even bent. They may be tremolite.

As to the origin of these slates, the structure is so unlike that of an ordinary slate that we can hardly believe them to be merely altered sediment. It seems more probable that they were originally tuffaceous sediments of a rather acid type; subsequent pressure has fractured the larger crystals, and recrystallisation has to some extent induced a flowage-structure, especially marked by the biotites, though the flowage-structure is in most specimens quite subordinate to the cataclastic structure.

The fifth group is that of the Knotted Slates. Their chief occurrence is in the railway cutting, between the augen slate band and the granite massif. They are fine-grained, grey, with a silky lustre and good cleavage. On cleaving, the flake will be seen to contain dents or lumps up to the size of a grain of wheat; and, if we polish the flake, the lumps will be found to have a black core. I have not sectioned a specimen of this slate from Newbridge, but an exactly similar rock occurs at the Wimburndale Creek, as is described by Curran;* and sections of it show the following characteristics—the predominant mineral is quartz showing rock-flowage. Brown biotite is very abundant, and runs in strings parallel to the schistosity; it is not very pleochroic. Carbonaceous matter is very abundant, and finely divided. Some tourmaline occurs, and small rutiles, both well crystallised. The black spots are aggregates of carbonaceous matter with some magnetite. In one instance the boundary of a spot is almost pure graphite, outside of which the biotites are arranged circumferentially, so that a wave of extension passes round the spot as the slide is rotated between crossed nicols. Generally the spot is elliptical, but this instance is in the form of a prism with terminal pyramidal faces. Inside the black border there is carbonaceous matter intimately mixed with green and brown biotite. These spots probably represented incipient andalusite or chiastolite crystals.

The second member of this group, Spotted Slate, is only the oxidised outcrop of the Knotted Slates. It occurs in a band running down the eastern side of the hill between Newbridge and the granites, that is a band parallel and near to the junction of slate and granite. This band is about 200 yards wide. In hand-specimen it is medium to fine-grained, soft and reddish,

* These Proceedings, 1891 (2), Vol. vii., p.201.

cleaves fairly well, showing a few glittering mica flakes on cleavage. The spots in it are quite black, and generally elliptical; and contain a good deal of mica. Microscopically, it differs from the knotted slates in that there is less carbonaceous matter; the biotites are chloritised and stained yellow with limonite; and muscovite occurs in large flakes lying across the general direction of schistosity. Small oxidising grains of magnetite occur; tourmaline and rutile as before.

Sixth Group: Chiastolite Slates.—These have so far been found only in the railway cutting just east of the large western granite vein, and about 200 yards east of the 164¾-mile peg. The specimens obtainable in the old railway cutting are better than those in the new. The slate appears first about two yards from the granite vein, and extends to 20 or 30 yards from it, the crystals becoming smaller as we pass outwards. In hand-specimen it is rather like the green slate, and has a fairly good cleavage. There are dark green rectangular prisms in it up to one-quarter of an inch in length, and surrounded by a bleached halo (Plate xxiii., figs.5, 6). Sometimes instead of the prism-form the black patches are in the shape of crosses, and may be with or without definite outline. Microscopically, the green main portion of the slate is seen to be very fine-grained, with rather larger crystals of biotite than usual, which are strongly pleochroic; though sometimes they may be partly chloritised. Sericite is scattered in wisps over the slide; there are some flakes of muscovite and a little magnetite. Rutile and tourmaline occur in their usual forms. Some andalusite is present as irregular grains. The bleached halos of the dark patches are composed of quartz, sericite, and muscovite only. The dark patches consist of a closely felted aggregate of biotite, muscovite, and a little quartz. I believe them to be decomposed chiastolite crystals.

The seventh group is that of the Mica Schists. These are the most metamorphosed of all the slates that occur in the district, and vary considerably in hand-specimen. Sometimes they are only distinguishable from the green slates by their coarser grain, and large flakes of muscovite. In this form they are generally very soft and decomposed. The band of mica schist that lies between the chiastolite slates and the granite vein is of this type. A second and more common type is seen among the granite veins nearer the massif. It has a very fair cleavage, and on the cleaved surface comparatively large flakes of mica can be seen. The mica is arranged in black layers which alternate with grey, finer-grained, less micaceous laminæ. Junction-specimens of slate and granite are easily obtained, and can with care be sectioned (see Plate xxiii., fig.3). Microscopically the slate is recognisable by its unusually large quartz grains, by the presence of fairly large orthoclases free from inclusions, the abundance and size of the muscovite flakes, and the complete absence of sericite and carbonaceous matters. Biotite occurs in bright red-brown crystals forming parallel bands which project from the slate into the granite for a short distance from the line of contact. This is probably due to the selective absorption of the schist minerals by the molten granite, the quartz being absorbed more than the biotite. The granite is devoid of coloured minerals for about one-eighth of an inch from the junction. Small rutiles occur in the slate, and some brown, pleochroic, perfect tourmaline crystals.

The schist that is in contact with the granophyre vein near the 163¼-mile peg is different from either of these types. It would be easy to mistake it in hand-specimen for a blue slate, save that it is black, and has not the same waxy translucency. Microscopically it is very highly crystalline, though of fine grain. Rock-flowage structure is typically developed. Quartz, biotite, and carbonaceous matter are the chief minerals. Large clear grains occur, with parallel rows of inclusions, and these Dr. Woolnough believes to be potential andalusites. This mica schist is very strongly intruded by the granophyre (see Plate xxiii., fig.4).

We have thus as a consequence of contact-metamorphism first, the formation of knots in the blue slates. These pass later into chiastolite crystals. By still further alteration the chiastolite slate passes into mica schist, which is the most metamorphosed of all the slates described. The felspathic and the augen slates cannot be regarded as products of contact-metamorphism, but rather of regional metamorphism; the sediment from which they were formed was not identical with that which has now become blue slate.

The other types of slates not mentioned above are merely the products of the weathering of the blue or knotted slates.

vi.—The Limestones.

The limestones occur in a group of lenticular beds near the Caloola gold mines, and some eight miles east of Newbridge. They were geologically examined by Mr. L. F. Harper* and economically reported on by Mr. A. L. MacCredie.† The greater part of them is leased to, and worked by, the Commonwealth Marble Quarries, Ltd. Five occurrences may be noted there, as under the number of each description referring to its position on the appended map (Plate xxiii.).

i. (Portions 104 and 115 of the Parish of Lowry). This is the seat of the main quarrying operations. The patch of limestone is about one-quarter of a mile long in a N.N.E. direction and five or six chains wide. It is composed of almost pure, white, crystalline marble; the grain-size is very even, about 1 mm. The marble is very solid, there being but few cracks or "dryers," so that large blocks are easily obtained. Along the dryers are dendrites, flakes and tufts of sericite, and occasionally crystals of chalcopyrite, galena, and actinolite, metasomatically replacing the limestone. In places the stone is completely replaced by a soft green steatite, fibres of which penetrate into the calcite grains. Microscopically, this seemingly homogeneous green mass is shown to be composed of practically colourless fibres of chlorite, recognised by its low double refraction, small optical axial angle, and optically positive character. There is also a little strongly birefringent talc or sericite, frequently in radiate groups, some

* Ann. Rept. Dept. Mines New South Wales, 1904, p.147.

† C.M.Q. Ltd., Prospectus.

corroded calcite, and many perfect rutile crystals, frequently geniculately twinned. At the Belmore Copper Mine (Cow Flat, Parish Ponsonby, and about five miles north-east of Caloola) this replacement of calcite by chlorite is very common, and here also the silicate actually associated with the ore is actinolite, so much so that the ore appears to be in a country rock of actinolite schist, which the microscope shows to be only a limestone almost entirely replaced by the actinolite. Mr. W. J. Clunies Ross, B.Sc.,* has analysed the chlorite and actinolite; he shows the chlorite to be a hydrous silicate of alumina; and, for the actinolite, he gives figures proving it to be essentially a magnesia-lime silicate with smaller amounts of iron and alumina. The analysis corresponds to a typical analysis of actinolite given by Dana.†

Seeing that, both at Caloola and at Belmore, the copper pyrites occurs with actinolite metasomatically replacing the limestone, it appears probable that the one solution deposited both of these minerals, *i.e.*, the sulphidic cupriferous solution also contained the silicate actinolite. The solution that brought up chlorite was probably connected with this same metalliferous solution. The Belmore vein appears to correspond more closely to the sericitic silver-copper type of Lindgren‡ than to any other of the types he mentions.

The marbles of the Caloola quarries have been analysed by the Department of Mines with the following result:—§

$CaCO_3$	97·07	84·78	97·71
$MgCO_3$	1·47	13·32	1·75
$Fe_2O_3 + Al_2O_3$	0·10	0·91	0·04
Insoluble	1·45	0·95	0·46
	100·09	99·96	99·96

These figures show that while dolomite does not appear to occur in the marble, magnesium carbonate is present in quite

* Report of the Seventh Meeting of the Australasian Assoc. Adv. Science, Sydney, 1898, p.384.

† System of Mineralogy, p.393.

‡ Genesis of Ore Deposits, p.596.

§ Ann. Rept. Dept. Mines New South Wales, 1904, p.147.

considerable quantities. This is quite in accordance with the results obtained by Prof. Skeats,* which show that up to fifteen per cent. of magnesium carbonate may be absorbed by a limestone before dolomite crystals appear. The question arises as to the cause of the presence of so much magnesium carbonate in the marble. Was it brought in by the metalliferous solutions, which were rich in magnesia; or was it introduced by replacement from sea-water while the limestone was still a coral-reef, after the manner described by Prof. Skeats? The latter I should imagine to be the case, for if the magnesia were derived from silicate solution it would probably be in accordance with an equation like the following

$$2CaCO_3 + MgSiO_3 = CaCO_3MgCO_3 + CaSiO_3$$

which would mean the formation of much wollastonite. Now, though I have seen a specimen of wollastonite said to have come from Caloola, I have not seen any *in situ*, and must hence believe it to be rare. Therefore, the reaction above could not have taken place on a large scale, and therefore the alternative origin of magnesia in the marble must have been the more important.

So far fossils have not been found in this quarry.

ii. (Portion 66, Parish Lowry). This is a narrow lens, less than three chains wide, crossing a small creek about three-quarters of a mile south of Occurrence No. i. It is a very fine-grained, good, solid marble, but its extent is not yet definitely settled. Probably it extends only a chain or two north of the creek, but may run further to the south. Major axis runs about N.N.E.

iii. (Portion 265, Parish of Ponsonby). This quarry, the first one to be worked, is situated a mile to the S. S.W. of No. i. It was originally worked for lime. The marble is of a rather finer grain than the previous occurrences, and in the exposed portions shows a pink or creamy colour. It is intersected by veins of almost colourless, coarsely crystallised calcite. Sericite and

* Bull. Mus. Comp. Zool. Harvard Coll., Vol. xlii., p.102 (1903).

chlorite occur as before, but ores are rarer. A few unmistakable traces of *Pentamerus Knightii* are to be seen on weathered surfaces. This fixes the age as Upper Silurian. Other markings occur, which may be corals but are very doubtful.

In extent this patch of limestone may be the largest of the group. To the north it is overlain by alluvium, while to the south it runs into a hill for some distance, for slate does not appear to outcrop for a long way to the south of it.

iv. (Occurs in the ∩-bend of the Caloola Creek, opposite Portions 100 and 99, Parish of Lowry). This is shown by a block of marble in the creek-bed, visible only at low water. If it is really *in situ*, it can be part only of a very small lens, for the slates appear to be *in situ* within 20 yards of it.

v. (At the northern end of Portion 99, Parish of Lowry). A small almost circular patch, about a chain across, and one-quarter of a mile south-west of the first occurrence here described. The marble is of good quality.

In none of the quarries has the junction between the slates and limestones been exposed, so that the dip of the strata here cannot, by this means, be determined yet. The strike, however, is N.N.E., as is shown by the direction of the major axes of the lenses of limestone. On the eastern side of Queen Charlotte Vale there is a series of limestone patches, some containing *Pentamerus knightii*, running approximately in this N.N.E. direction through Cow Flat, and terminating on the Mount, where they are highly dolomitised, and contain 43·73 per cent. of magnesium carbonate.* If we continue on the same direction from here across the granites of the Bathurst Plains, we again come on limestones at Fernbrook, and at Limekilns, very rich in fossil content, *Stromatopora*, *Favosites*, *Phillipsastræa* and some Pentameri.† There thus appears to have been a continuous horizon, with a N.N.E. strike, extending for 30 miles. As to its dip, there is little definite evidence. The Belmore copper lode

* W. Clunies Ross, Rept. Aust. Assoc. Adv. Sci. 1898, p.384.

† W. Clunies Ross, Q.J.G.S. 1894, p.113.

near Cow Flat has the same strike, and dips W. 20 N. at 45°. This may be the dip of the strata in that locality.

vii.—Economic Minerals.

Gold.—In the early days there was a good deal of shallow digging near Newbridge in what is now the railway reserve; but it was never very satisfactory, and has entirely ceased.* Lately, however, a mine has started in the western part of the Parish near the andesites (Portions 20 and 22), and cyanide vats are to be set up. The great quartz reef (see p.534) has been much prospected but is barren. The mine at Caloola has been worked successfully for some time, the gold occurring in a soft, highly oxidised slate.

Dredging has been carried on with some success in the valley to the north, just outside the Galbraith Parish boundary, where in the alluvium brought down by the Reedy Creek, consisting of slate, andesite, and a little granite débris, payable gold was found on the granite floor at a depth of about 25 feet. This dredge, has, however, lately closed down.

Silver.—Some silver ore was reported from here,† and a shaft was put down on Portion 29, Parish Galbraith, just near the southern end of the hæmatite veins. Nothing payable was found.

Lead has been reported from this district,‡ but I did not learn that any mining had been done for it.

Copper.—Within the district described in this paper no payable copper lodes have yet been discovered. Traces were found in the making of the new railway cutting, and a lease was pegged out, but nothing done. Mr. J. E. Carne reports a find of sulphide ore from Colo Creek,§ near Newbridge, but that is outside the area here described; nor, so far as I know, has any mining been

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* Pittman, "Prospectors' Guide," p.16, 1905.

† E. F. Pittman, Min. Resources of New South Wales, p.127.

‡ Pittman, *op. cit.* p.192.

§ Geol. Surv. New South Wales. Mineral Resources No.6. "The Copper Mining Industry," &c.(1899), p.76.

done there. Copper pyrities occurs, as previously described, in the marble at Caloola. But its chief occurrence near Newbridge is at Cow Flat, where there are two lodes, worked respectively by the Cow Flat Mine,* now closed, and the Belmore Mine (Lloyd)† still working. The surface indications of both these lodes is very distinct, being marked by hæmatite, malachite, and a little azurite. Actinolite schist, a lime-silicate rock, is the country rock, and associated are chlorite limestone and slate.

Iron.—The iron ore deposits of Newbridge, though rather small, are of excellent quality. They were described by Mr. J. E. Carne, F.G.S., in 1891.‡ The lode runs in a north-westerly direction from Portion 91 of Galbraith Parish, across Portions 104 and 108, where it is very poor, and appears again in the Railway Reserve, and in Portion 59; it is said to have been followed some miles to the north of this. A large amount of ore has been taken from the outcrop in the reserve, and a typical analysis of it is given in Mr. Carne's report (*op. cit.* p.150).

The southernmost opening on Portion 91 shows very good specimens of hæmatite, sometimes stalactitic; but as a whole the lode here is very siliceous. The intermediate outcrops in Portions 108 and 104 are useless.

This lode is, according to Mr. Carne, "a fissure vein extending for several miles, and locally thickening at the parts opened up. There is yet no indication of its depth and whether or not it passes into pyrites at the water-level. It is still solid hæmatite at 35 feet deep. The walls of the lode are nearly vertical, inclining slightly to the east."§

At Caloola in the oxidised slates that are crushed for gold, there are frequent limonite pseudomorphs after perfectly crystallised pyrites, which are up to one inch across. The deepest workings of the gold mines, 50 feet, are still in the zone of oxidation.

* *Op. cit.* p.82.

† *Op. cit.* p.52.

‡ Ann. Rept. Dept. Mines New South Wales, 1892, p.150.

§ J. B. Jaquet, "Iron Ore Deposits of New South Wales," p.138 (1901).

Manganese.—At the inner end of a tunnel on either G.L. 271 or 262, Parish Ponsonby near Caloola, there is a vein three feet wide of soft crumbly, but seemingly fairly pure wad; other veins occur in the hill. Considering the low price of manganese, it appears to me very doubtful that these can be worked to any profit.*

Marble.—Large blocks can be easily obtained from the Caloola quarries. It is of excellent quality, has been used for statuary, pavements, steps, &c.†

Slate.—A quarry was opened up on Portion 42 of the Parish of Galbraith, and a good deal of stone removed; its poor fissility prevents it from being used for roofing slate. It could, however, be used for flagging, kerbstones, shelvings, &c., though rather soft.‡ It is very fine-grained, black, lustrous. The analysis of this slate was given on p.537.

Asbestos.—As described previously, this occurs in narrow veins, is short in fibre, and brittle. Also there is very little of it. It cannot therefore be of much use commercially.

Diatomaceous Earth.—An occurrence has been recorded from near Newbridge,§ but I was unable to get any information about it locally.

viii.—Summary.

In the foregoing an endeavour has been made to show in some detail the geological and petrographical features of the Newbridge district. It has been shown that the oldest rock is slate, probabably Ordovician, interbedded with contemporaneous andesite flows; and that higher in the series the slate is Silurian, as proved by the presence of *Pentamerus Knightii* in the inter-

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* Pittman, "Min. Resources of New South Wales," pp.243-4.

† *Op. cit.* p.434; also L. F. Harper, Ann. Rept. Dept. Mines New South Wales, 1904, p.147.

‡ Pittman, "Min. Resources of New South Wales," p.446.

§ Rec. Geol. Surv. N. S.Wales, Vol. v. p.147.

bedded, lenticular beds of limestone. The andesites are a portion of a large area stretching out to the west, and are rather decomposed and uralitised, sometimes with the formation of tremolitic asbestos. The slates have been intruded by a large granite massif, part of that which forms the Bathurst plains, which sent into the slate such vein-rocks as granite, granophyre and aplite. The slate was considerably metamorphosed by these, both at the contact and to some extent regionally. A good series of contact-metamorposed slates can be traced towards the massif, viz., slate passing into knotted slate, chiastolite slate, and mica slate. Felspathic and augen slates also occur, but these are more correctly referable to regional metamorphosis.

The limestone has become marble, and in favourable localities has been metasomatically replaced by copper ores, or changed by a similar process into actinolite schists. The occurrence of a chlorite schist has been noted, but its mode of origin at present remains unexplained. Lastly, the economic minerals have been briefly described, and it has been shown that marble, iron ore, and gold are the only minerals in this district likely to be of much value.

ix.—Conclusion.

I am indebted to Mr. L. V. Puckle, Secretary to the Commonwealth Marble Quarries, Ltd., for information concerning, and permission to inspect, the marble quarries; and to his quarry manager, Mr. F. T. Campbell, for pointing out the smaller occurrences of marble.

Mr. H. J. Meldrum, B.Sc., has very kindly analysed the slate for me. My thanks are especially due to Dr. Woolnough, for much advice and assistance in the preparation of this paper and its illustrations.

Note.—Since writing the above, I have learnt, from Mr. R. H. Cambage, that basalt occurs capping Sugarloaf Hill. This is on the northern border of Galbraith Parish, and I was unable to visit it.

EXPLANATION OF PLATES.

Plate xxii.

Geological Map of Newbridge.

Plate xxiii.

Fig. 1.—Andesite from Smith's Hill. At the top a large crystal of augite may be clearly seen, and below it a mass of fibrous chlorite. The crystals of felspar stand out clearly against a matrix of decomposed glassy matter.

Fig. 2.—The granophyre referred to on page 532. As may be seen, it is a perfect example of an intergrowth of quartz and felspar.

Fig. 3.—A junction of mica slate and granite. The latter has absorbed a little of the colourless part of the slate as may be seen from the fact that the biotites project into the granite. This specimen is remarkable for the coarseness of grain of the mica slate.

Fig. 4.—A junction of mica slate and granophyre. This is very different from Fig. 3. The slate is finer-grained, and contains much magnetite. The granophyre has greatly disrupted the slate. Note the potential andalusite crystal on the lower margin.

Fig. 5.—Chiastolite slate. The chiastolite occurs in black, rectangular grains; and is sometimes in a cruciform twin.

Fig. 6.—Chiastolite slate. Notice the light halo round each crystal. A centimetre scale is shown to give an idea of the size of the crystals.